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Radiation level over the Bishnumati River Bridges: A study from Balaju to Teku in Kathmandu, Nepal

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Abstract

The presence of background radiation is ubiquitous, extending even to bridges. Notably, the bridges spanning the Bishnumati River are situated close to solid waste collection centers, garages, and significant religious sites such as Shovabhagwati, Indrayani, and Kankeswori. This study aims to assess the radiation exposure levels across 14 different bridges along the Bishnumati River, from Balaju to Teku, utilizing a professional Digital Geiger Counter GCA-07W. The surveyed bridges encompass various types, including vehicle, bailey, and semi-suspension bridges. Results reveal that the Shovabhagwati bridge exhibits the highest annual effective dose rate at 1.025 ± 0.230 mSv/yr, while the Nilbarahi bridge records the lowest at 0.696 ± 0.237 mSv/yr. Remarkably, the vehicle-cemented bridge displays elevated background radiation, attributed to the construction materials, such as cement, iron rods, and other components. The average annual effective dose across all surveyed bridges is 0.906 ± 0.230 mSv/yr, remaining below the recommended dose set by the International Commission on Radiological Protection (ICRP). Importantly, no harmful radiation levels are detected between Balaju and Teku along the Bishnumati River bridges in Kathmandu, Nepal. This study contributes valuable insights into the radiation landscape of these structures, offering reassurance regarding public safety within the surveyed area.

Keywords
Background radiation, Geiger counter, exposure, annual effective dose (AED)

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1 Introduction

Background radiation, a ubiquitous phenomenon in the natural environment, constitutes a continuous presence in our surroundings. Individuals are consistently exposed to this natural background radiation, which varies based on factors such as the presence of radionuclides in the Earth's crust, altitude, industrial activities, and anthropogenic byproducts. The decay of natural radionuclides like uranium and thorium results in the formation of radium and radon, disseminating into soil, water, plants, and air. Radon, notably, stands as the largest contributor to natural radiation exposure [1] as shown in Figure 1 [2]. The release of uranium into the environment occurs through natural events like forest fires, volcanic activities, weathering, and erosion of rock and soil. Consequently, uranium and its decay products are assimilated by plants and animals, eventually reaching humans through inhalation, ingestion, and absorption from food, water, and air [3].

Average activity levels of all radio-nuclides were found to surpass the global average, aligning with the geological and geochemical characteristics of the investigated area's rocks [4]. Soil samples from diverse locations indicated the potential for radon concentrations in dwellings to exceed the recommended level of 300 Bq/m^3 for residential areas [5]. Soil samples in the Kathmandu Valley displayed varying radon exhalation rates, corresponding to the indoor radon exhalation of dwellings [6]. Sundhara exhibited the lowest average dose rate, while Budhanilkantha recorded the highest. The Kathmandu Valley's average annual effective dose of 0.475 mSv/yr [7] is slightly lower than the global terrestrial average of 0.5 mSv/yr [3]. Building materials studied in the region, except for gneiss rocks from Shai hills with elevated cancer risk, were deemed safe for construction [8]. In Pokhara city, diverse locations showed varying dose rates, with the average annual effective dose rate of 0.56 mSv/yr falling within recommended levels and comparable to Kathmandu city's average annual effective dose [9].

While numerous surveys have explored background radiation in various locations of Nepal and the Kathmandu Valley, there is a notable gap concerning bridge structures. Bridges, serving as connections between riverbanks, involve excavation during construction, potentially releasing more radon into the air and increasing concrete-related radiation. This study aims to assess background radiation on 14 bridges spanning the Bishnumati River, evaluating whether the measured exposure dose exceeds reference levels.

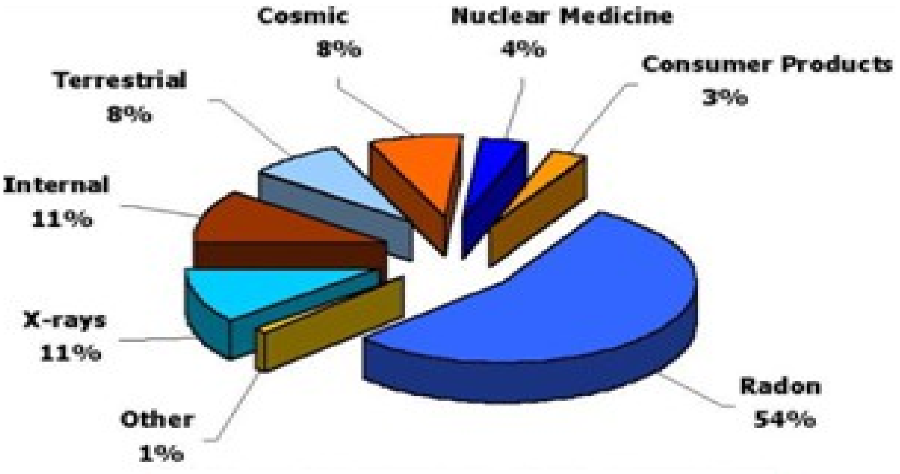

Figure 1: Sources of natural background radiation [2].

2 Material and Methods

The GCA-07W professional GM counter [10], as depicted in Figure 2, was used in this work to measure radiation levels at 14 different bridges spanning from Balaju to Teku over the Bishnumati River during the period of 19-23 July 2020. The selection of bridges for this study was driven by the potential impact of local environmental factors, such as waste disposal sites and cremation centers, on background radiation levels. Furthermore, the study was conducted during the COVID-19 pandemic to capitalize on reduced human activity and traffic, thereby minimizing external variables that could affect the accuracy of radiation measurements. Consequently, all 14 bridges spanning the Bishnumati River within the core area of Kathmandu city have been chosen for our present study. A geographical overview of the selected area is presented in Figure 3, capturing a screenshot or picture of the original map.

Figure 2: GCA-07W Geiger counter [10].

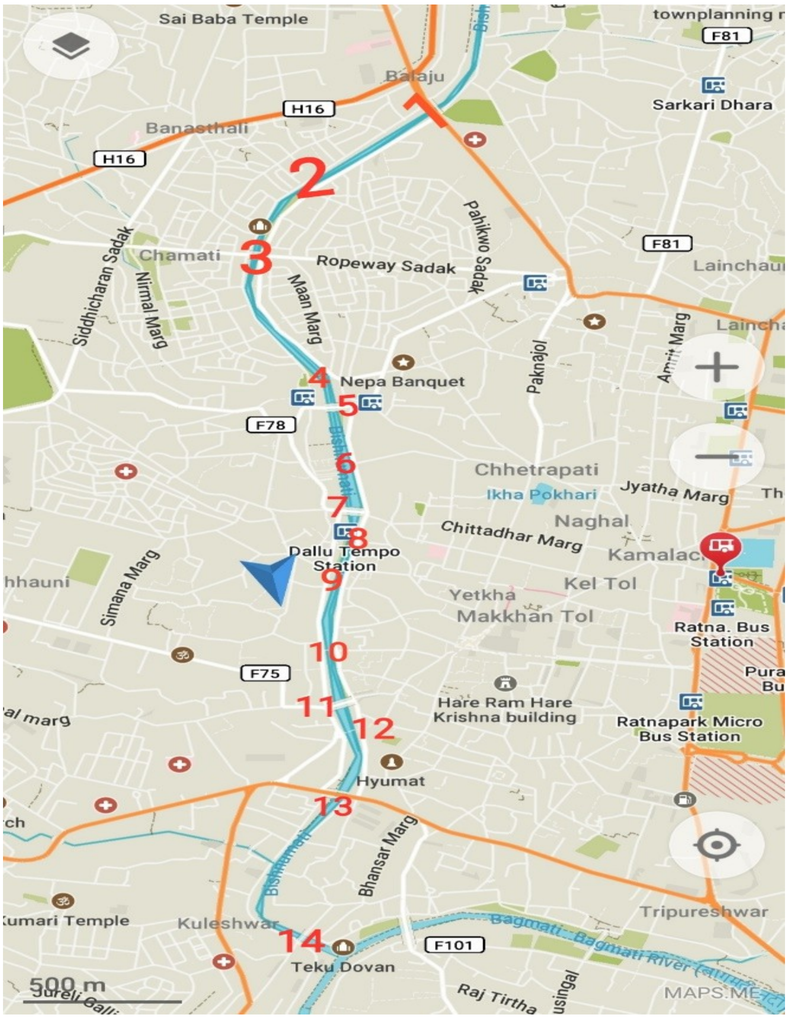

Figure 3: Geographical overview of the study area with locations of the bridges.

To ensure data accuracy, 30 different measuring points were sampled on each bridge. The average dose and standard deviation for each bridge were computed, considering measurements taken on the northern side, southern side, and middle of the bridges. This method allows for a comprehensive assessment of background radiation across the selected bridges, taking into account potential variations in exposure levels at different points on each structure. The GM counter was positioned one meter above the ground during data collection, with counts per minute (CPM) converted to annual exposure rates. The annual effective outdoor dose rate for background radiation was calculated using the following expression:

$$AED = D\left(\frac{mSv}{hr}\right) \times \frac{8760hr}{yr} \times 0.2 \times 0.7 \quad (1)$$

where D is the outdoor dose rate, 8760 is the conversion factor of hours per year, 0.2 is the outdoor occupancy factor and 0.7 is the conversion factor [11].

3 Results and Discussion

The outdoor exposure rates for 14 different bridges are presented in Table 1. In the Table, the second to fifth columns represent the names of the bridges, their GPS coordinates, average exposure rates, and annual effective dose rates, respectively. The values in the brackets of columns four and five represent their corresponding standard deviations. Table 1 indicates that the Shovabhagwati Bridge exhibits the maximum outdoor background radiation, whereas the minimum value is observed at the Nilbarahi Bridge. The radiation values of the other bridges fall within these two extremes. Data from the table are also presented graphically in Figure 4 for better interpretation.

Figure 4 illustrates the annual effective dose of all 14 bridges on the Bishnumati River, ranging from 0.696 to 1.025 mSv/yr. The Nilbarahi Bridge records the minimum, while the Shovabhagwati Bridge shows the maximum annual effective dose. The average annual effective dose for all 14 bridges on the Bishnumati River is 0.906 ± 0.230 mSv/yr, slightly higher than previous works [7–9], but within the annual effective dose limit of 1 mSv/yr recommended by the ICRP for the public [12].

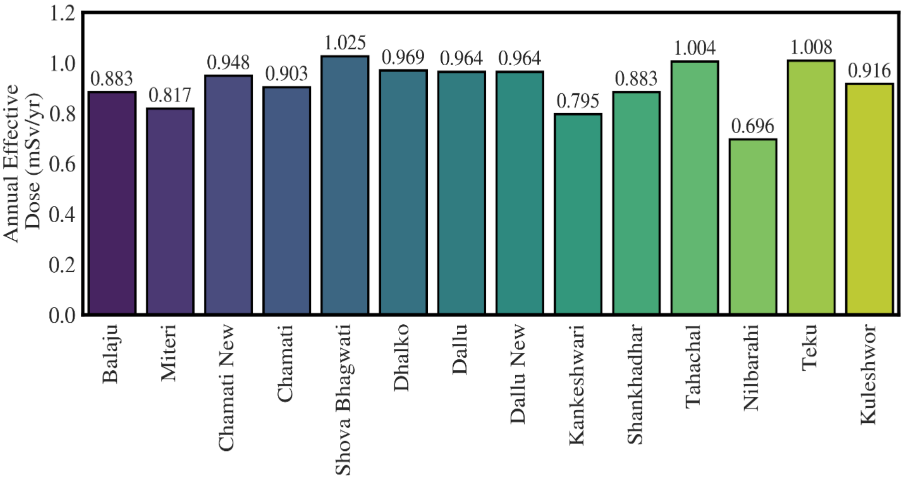

Figure 4: Annual effective dose of different bridges on the Bishnumati River from Balaju to Kuleshwor (Teku), Kathmandu, Nepal.

Table 1: Effective dose from natural background radiation on the 14 bridges over the Bishnumati River.

S.N.	Bridges	GPS Coordinate	D (mSv/yr)	AED (mSv/yr)
1	Balaju	27.7255 N, 85.3053 E	0.720 (0.151)	0.883 (0.185)
2	Miteri	27.7225 N, 85.3013 E	0.666 (0.168)	0.817 (0.206)
3	Chamati New	27.7197 N, 85.2995 E	0.773 (0.181)	0.948 (0.221)
4	Chamati	27.7137 N, 85.3022 E	0.736 (0.198)	0.903 (0.242)
5	Shovabhagwati	27.7149 N, 85.3017 E	0.836 (0.188)	1.025 (0.230)
6	Dhalko	27.7117 N, 85.3025 E	0.790 (0.235)	0.969 (0.288)
7	Dallu	27.7094 N, 85.3029 E	0.786 (0.179)	0.964 (0.219)
8	Dallu New	27.7088 N, 85.3027 E	0.786 (0.193)	0.964 (0.236)
9	Kankeswori	27.7069 N, 85.3022 E	0.648 (0.192)	0.795 (0.235)
10	Shankhadhar	27.7038 N, 85.3053 E	0.720 (0.151)	0.883 (0.185)
11	Tahachal	27.7255 N, 85.3020 E	0.819 (0.160)	1.004 (0.196)
12	Nilbarahi	27.7008 N, 85.3026 E	0.568 (0.194)	0.696 (0.237)
13	Teku	27.6980 N, 85.3023 E	0.822 (0.233)	1.008 (0.285)
14	Kuleshwor	27.6923 N, 85.3010 E	0.747 (0.147)	0.916 (0.180)

The observed exposure rates in this study are lower than the global average and remain within acceptable levels. Although these rates are higher than previous findings [7, 8, 9], they do not pose a major concern for public safety. Therefore, the public can continue their activities without restriction, but caution is advisable.

4 Conclusions

This study assessed the background radiation doses of 14 bridges spanning the Bishnumati River from Balaju to Teku. The findings reveal that the Shovabhagwati Bridge exhibits the highest annual effective dose rate at 1.025 ± 0.230 mSv/yr, while the Nilbarahi Bridge records the lowest at 0.696 ± 0.237 mSv/yr. Notably, cemented-motorable bridges demonstrate a relatively higher radiation exposure compared to non-motorable bailey or suspension bridges. Three bridges, namely Shovabhagwati, Tahachal, and Teku, slightly exceed the recommended dose, while all other bridges maintain doses below the recommended levels. On average, the cumulative dose remains well below the limit for public exposure. Consequently, it can be concluded that the background radiation levels on these bridges pose no hazard to the general public. These results establish a baseline, indicating the absence of biologically hazardous radiation pollution, rendering these bridges safe for public exposure to natural radiation. Future work is recommended, including an exploration of the correlation between bridge materials and radiation levels. Additionally, further investigation into seasonal radiation variations over the bridges may provide valuable insights. These avenues of research can contribute to a more comprehensive understanding of the factors influencing radiation levels on bridges and help enhance safety measures for public infrastructure.

References

[1] `https://www.epa.gov/radtown/background-radiation` (accessed on August 15, 2020)

[2] `http://2.bp.blogspot.com/oHlSWLrUqW0/UiAQLu13ySI/AAAAAAAAIjQ/Cejdt4RXY54/s1600/Background-Radiation1.jpg` (accessed on August 10, 2020).

[3] United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, effects and Effects of ionizing radiation Annex B. *Exposures from Natural Radiation Sources. United Nations: New York.*,2000

[4] C. Ningappa, J. Sannappa, and N. Karunakara. Study on radionuclides in granite quarries of Bangalore rural district, Karnataka, India. *Radiation Protection Dosimetry*, 131:495–502, 2008.

[5] F. Girault, A. P. Gajurel, F. Perriera, B. N. Upreti, and P. Richon. Radon emanation of heterogeneous basin deposits in Kathmandu valley, Nepal. *Journal of Asian Earth Sciences*, 40:595–610, 2011.

[6] P. Parajuli, D. Thapa, and B. R. Shah. Study of radon exhalation rate in soil samples of Kathmandu valley using passive detector LR115. *International Journal of Chemical and Physical Sciences*, 4:30–39, 2015.

[7] P. Pantha, T. P. Bhusal, B. R. Shah, and R. P. Koirala. Study of natural background radiation in kathmandu valley. *Bibechana*, 16:187–195, 2018.

[8] F. Otoo, E. O. Darko, M. Garavaglia, C. Giovani, S. Pividore, A. B. Andam, J. K. Amoako, O. K. Adukpo, S. Inkoom, and S. Adu. Public exposure to natural radioactivity and radon exhalation rate in construction materials used within Greater Accra Region of Ghana. *Scientific African*, 1:e00009, 2018.

[9] S. P. Gautam, A. Silwal, S. Acharya, and B. Aryal. Annual effective dose from natural background radiation in Pokhara, Nepal. *Asian Journal of Research and Reviews in Physics*, 3:36–42, 2020.

[10] `https://www.imagesco.com/geiger/digital-geiger-counter.html` (accessed on August 15, 2020).

[11] United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, effects and risks of ionizing radiation. *Report to the General Assembly, with Annexes*, 1988.

[12] A. D. Wrixon. New ICRP recommendations. *Journal of Radiological Protection*, 28:161, 2008.